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(54) Stamp formed exhaust muffler with conformal outer shell.

(57) A stamp formed exhaust muffler (10) for mounting on a vehicle is provided. The muffler (10) comprises a plurality of plates (12, 14) secured in juxtaposed relationship and stamp formed to define an array of tubes therebetween. At least one external shell (16, 18) is secured to the internal plates (12, 14) to define at least one chamber which communicates with the array of tubes. The external shell (18) includes a conformal area (66) which permits the muffler to conform to the shape of a structure on the vehicle. The conformal area (66) may be an area of generally arcuate concavity when viewed from the exterior of the muffler or may define an internal corner on the muffler. Thus, a plane or line connecting two locations on the conformal area of the external shell will pass through the interference zone of a structure on the vehicle.

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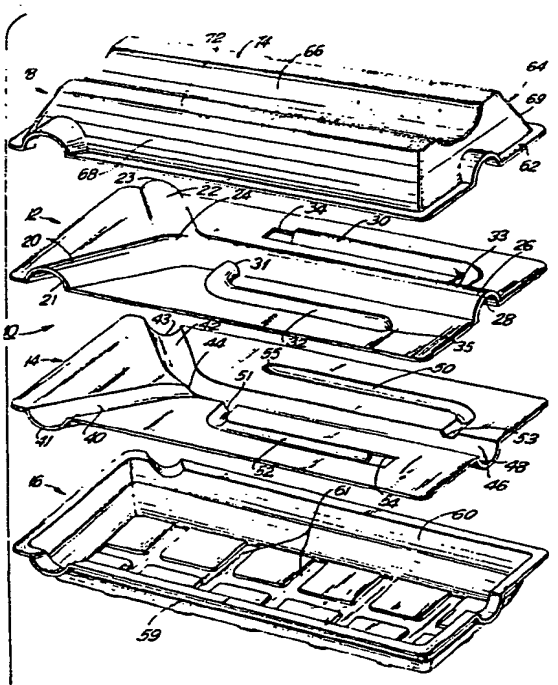

FIG. 1

STAMP FORMED EXHAUST MUFFLER WITH CONFORMAL OUTER SHELL

BACKGROUND OF THE INVENTION

Prior art vehicular exhaust mufflers typically comprise an array of parallel tubes supported by transversely extending baffles and mounted within a generally tubular outer shell of circular or oval cross section. The array of tubes in the prior art muffler typically comprises an inlet tube connectable to the exhaust pipe coming from the engine, an outlet tube connectable to the tail pipe and one or more additional tubes to provide communication between the inlet and outlet. The baffles of the prior art muffler typically conform to the cross-sectional shape of the outer shell such that the baffles and the outer shell define a plurality of chambers within the muffler. The pipes disposed in the prior art muffler communicate with one or more of the chambers. For example, certain pipes extending through a chamber might be perforated or louvered to allow the exhaust gases to expand into the chamber and/or to permit a controlled amount of cross flow between two perforated tubes in the expansion chamber. The prior art muffler could also include a tuning tube extending into an at least partly enclosed low frequency resonating chamber for the purpose of attenuating a fairly narrow range of low frequency noise.

The noise and pressure characteristics of exhaust gases vary widely from one engine type to another. Thus, exhaust mufflers are carefully engineered for each vehicle engine type to ensure that the muffler attenuates noise properly for its intended vehicle and achieves the specified levels of noise and back pressure. The parameters that affect these performance characteristics include the cross-sectional area of the tubes within the muffler, the cross-sectional area encompassed by perforations or louvers, the length and cross-sectional dimensions of tuning tubes, the volume of the various low frequency resonating chambers and expansion chambers and so forth.

In addition to the acoustical design parameters, automotive engineers must contend with the limited available space on the vehicle. In particular, other structures on the vehicle such as the gas tank, the passenger compartments, the trunk and spare tire well, the drive train and suspension components typically have set volume and location requirements that limit the number, the size and the shape of the locations available for the muffler. Additionally, most automobile manufacturers establish sight lines and ramp clearances above which all structural components, including the exhaust system, must be disposed. These various space limitations and controls have imposed severe design constraints and limitations on the manufacturer of the prior art mufflers. In particular, the muffler manufacturer could alter the length of the prior art muffler to fit the available space and could select an appropriate size oval or circular cross section in an attempt to match the space envelope on the vehicle. However, in virtually all situations, the manufacturer of the prior art muffler was limited to generally rectangular top, bottom and side plan view configurations of the muffler and a circular or oval transverse cross section. As a general rule, it becomes increasingly more difficult to achieve specified noise and back pressure levels as the volume or size of the muffler is decreased. Smaller mufflers tend to increase back pressure and limit the number of acoustical tuning options that are available.

The prior art includes various stamp formed mufflers. Many of these prior art stamp formed mufflers have comprised a pair of stamp formed plates secured in juxtaposed relationship, with the stamp forming defining a circuitous route for the exhaust gases to follow. The particular circuitous route of these prior art stamp formed mufflers was intended to attenuate the exhaust gas noise. Examples of such prior art mufflers include U.S. Patent No. 2,484,827 which issued to Harley on October 18, 1949 and U.S. Patent No. 3,638,756 which issued to Thiele on February 1, 1972. Other prior art stamp formed mufflers have included at least one pair of stamped internal plates which define tubes and/or baffles and a pair of stamped external shells to define an enclosure around the internal plates. Prior art mufflers of this general construction are shown in: U.S. Patent No. 4,132,286 which issued to Hasui et al on January 2, 1979; U.S. Patent No. 4,456,091 which issued to Blanchot on June 26, 1984; and British Patent No. 632,013 which issued in 1949. Other prior art mufflers have included stamp formed external shells with internal components comprising both tubular and stamp formed components, such as the muffler shown in Japanese Patent No. 59-43456, while still others have included stamp formed internal components with conventional wrapped outer shells, such as the muffler shown in U.S. Patent No. 4,396,090 which issued to Wolfhugel on August 2, 1983.

Recently there have been several significant engineering improvements in mufflers fabricated from a plurality of formed sheets of metal. In particular, the metal sheets of these mufflers are appropriately deformed by available processes such as stamp forming, hydroforming, explosion forming or magnetic forming. For example, a formed muf-

fler with an array of tubes including tuning tubes and with low frequency resonating chambers and expansion chambers is shown in U.S. Patent No. 4,700,806 which issued to Jon Harwood on October 20, 1987 and which is assigned to the assignee of the subject invention. The mufflers shown and described in U.S. Patent No. 4,700,806 affords many engineering and manufacturing advantages in view of its stamp formed construction, while also achieving sound attenuation options that had not previously been available with stamp formed mufflers. The disclosure of U.S. Patent No. 4,700,806 is incorporated herein by reference.

As noted above, the prior art conventional muffler formed with tubular internal components, baffles and a wrapped outer shell is typically of generally rectangular configuration in its top, bottom and side plan views and oval or circular in transverse cross section. Also as noted above, this limitation on the shape of the muffler has created significant challenges to the automotive engineers attempting to design the exhaust system within the limited space envelopes on the vehicle. The above described prior art stamp formed mufflers have also generally conformed to this rectangular plan view configuration to define a generally convex polyhedral external shape. However, certain of these prior art stamp formed mufflers have somewhat softened the polyhedral configuration with tapers at the opposed ends, such as in the above referenced U.S. Patent No. 3,638,756 and U.S. Patent No. 4,132,286. U.S. Patent No. 4,700,806 also shows that the rectangular side elevational view can be altered with a tapered end wall.

Further advancements in muffler construction are shown in co-pending patent application Serial No. 061,876 which was filed by Jon Harwood et al on June 11, 1987 and is directed to an exhaust muffler with angularly aligned inlets and outlets. In particular, co-pending application Serial No. 061,876 shows a generally polyhedral exhaust muffler of generally pentagonal top plan view configuration achieved by truncating one corner of an otherwise rectangular top plan view to enable the muffler to be placed in proximity to the differential of a rear wheel drive vehicle. Co-pending application Serial No. 061,876 further shows that the stamp formed construction enables the inlets and outlets of the muffler to be angularly aligned relative to one another and relative to the centerline of the muffler, and further enables at least one inlet or outlet to extend from the top or bottom of the muffler, thereby obviating the need for long tubular bends and enabling the muffler to be placed in closer proximity to other structures on the vehicle. A similar disposition of a muffler inlet and/or outlet is shown in co-pending application Serial No. 061,913 which also was filed by Jon Harwood on June 11, 1987 and is directed to the tube and chamber construction for an exhaust muffler. These co-pending applications are assigned to the assignee of the subject invention and their disclosures are incorporated herein by reference.

Several of the above identified prior art references show stamp formed mufflers where the external shells include indentations to achieve or contribute to a particular required circuitous flow of exhaust gases. For example, the above described U.S. Patent No. 4,700,806 and the co-pending applications all show formed mufflers wherein the external shells include creases or indentations which extend into contact with the internal plates to define chambers surrounding the array of tubes in the muffler.

Despite the significant recent advances in stamp formed mufflers, the mufflers have defined an exterior profile or space envelope, relative to other parts of the vehicle, of generally convex polyhedral shape. It is now realized that this geometric limitation may create difficulties in attempting to position an acoustically acceptable muffler within the limited space on a vehicle.

In view of the above, it is an object of the subject invention to provide a muffler comprising a plurality of stamp formed components configured to conform closely to the shape of other structures on the vehicle.

It is another object of the subject invention to provide a muffler having a plurality of stamp formed external shells, at least one of which is stamped to conform to the available space on a vehicle.

An additional object of the subject invention is to provide a muffler having at least one stamped external shell which is generally concave in configuration and conformal with respect to at least one other structural component on a vehicle.

A further object of the subject invention is to provide a vehicular exhaust muffler having a plurality of external shells, at least one of which is concave to substantially follow an interference zone surrounding at least one other structural component on a vehicle.

Still a further object of the subject invention is to provide an exhaust muffler having at least one external shell configured to at least partly surround another structure on the vehicle.

SUMMARY OF THE INVENTION

The subject invention is directed to a muffler comprising a plurality of formed sheet metal components. Typically, the metal sheets are formed by stamping, but other known forming methods can be

employed, such as hydroforming, explosion forming or magnetic forming. As used herein, the terms forming and/or stamp forming are considered to comprise all such forming methods where forces are applied to a sheet to achieve a specified form. The muffler may comprise a pair of plates secured in juxtaposed relationship and formed to define an array of tubes therebetween. The plates may initially be separate, or may be a single plate folded onto itself. The array of tubes comprises at least one inlet and at least one outlet to the muffler. Selected locations on the plates may be formed to include perforations, louvers or apertures which permit a controlled flow of exhaust gases from the array of tubes at locations between the inlet and outlet.

The muffler further comprises at least one external shell secured to the plates. The external shell is formed to define at least one chamber surrounding selected portions of the plates, such as portions that have been stamped to include perforations, louvers, apertures or the like. In certain embodiments the muffler may comprise a pair of stamp formed plates secured in face-to-face relationship and a pair of stamp formed external shells secured to and surrounding the plates.

At least one external shell has a portion which is of generally concave conformal configuration with respect to at least one other nonplanar or polyhedral structure on the vehicle. In this context, "conformal" is defined as conforming to the shape of some other nonplanar structure on the underside of the vehicle or the interference zone specified for that other structure. Also in this context "concave" is intended to encom pass both an inwardly directed arcuate surface or an inwardly directed area defined by two intersecting surfaces such as on a concave polyhedron. Thus, the concave conformally configured external shell of the muffler will effectively surround a generally convex portion of the other structure on the vehicle or the interference zone of that other structure. With this construction, a line or plane connecting spaced apart locations of the conformal area of the external shell will pass through either another structure on the vehicle or the interference zone surrounding such other structure. More particularly, a line or a plane connecting the extremes of the conformal area on the muffler may pass through an unrelated structure on the vehicle or through the interference zone of that structure.

To clarify the configuration of the subject muffler, it must be noted that in this context the muffler is not considered to comprise the inlet or outlet nipples extending therefrom and that the conformal area does not include an inlet or outlet nipple of the muffler. Additionally, the other structures of the vehicle to which the subject muffler conforms in shape do not include mounting brackets and other such hardware for securing the muffler to the vehicle. In this regard, the prior art does show both conventional and stamp formed mufflers where a mounting bracket is disposed in the corner defined between an inlet or outlet nipple and an end wall of the muffler.

In certain embodiments the muffler may comprise a pair of internal plates secured in face to face relationship to define an inlet and an outlet and a pair of tuning tubes disposed therebetween. The muffler may further comprise a pair of stamp formed external shells. One tuning tube may communicate with a low frequency resonating chamber defined by one external shell and one internal plate, while the other tuning tube may communicate with a low frequency resonating chamber defined by the other internal plate and the other external shell. This muffler may be configured to be disposed generally in line with the drive shaft of the vehicle. Thus, the stamp formed external shell which will be disposed generally in face-to-face relationship with the underside of the vehicle will be stamp formed to define an elongated concave portion to conform to the shape of the drive shaft and the interference zone surrounding the drive shaft. This concave portion may terminate at two spaced apart generally parallel ridges. The portion of the muffler between these ridges would be spaced inwardly from a line or plane connecting the two ridges. Furthermore, when the muffler is mounted to the vehicle a chordal line or plane connecting these ridges would pass through the interference zone surrounding the drive shaft, and in certain embodiments would extend through the drive shaft as well. Preferably, the muffler would conform to the shape of the interference zone. More particularly, the conformal area of the muffler may be generally uniformly spaced from the drive shaft. This ability to form the external shell to partly surround the drive shaft greatly facilitates the ability to achieve the required volume for the low frequency resonating chamber within the limited available space on the vehicle. As noted above, larger volumes may be critical for achieving specified noise levels without unacceptably raising back pressure. The opposed external shell of the muffler would be facing the road or other surface on which the vehicle is supported, and would not necessarily require a concave configuration. Rather, the other external shell of the muffler would be provided with a configuration to ensure that the entire muffler is within the specified sight lines, achieves the required ramp clearance and is consistent with the desired aerodynamic shape of the vehicle.

Another possible muffler configuration would include a pair of plates stamp formed to define an inlet and outlet and an array of tubes therebetween.

The external shells would be stamp formed to generally define a concave polyhedron with an inwardly directed corner which conforms to the shape of the trunk well, the spare tire well or the passenger compartment. This internal corner may be formed by two intersecting generally planar surfaces of the external shell or two distinct arcuate surfaces of the external shell. A line or plane connecting selected locations on these two intersecting surfaces would pass through the trunk well, spare tire well or other such structure on the vehicle or the interference zone surrounding such other structure. For example, the inwardly directed corner may be defined by two generally planar surfaces which extend away from the inwardly directed corner to two respective external or outwardly directed corners. A line connecting these two external corners would pass through the adjacent part of the vehicle or through the interference zone of such adjacent part, and would be spaced away from parts of the muffler therebetween.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an exploded perspective view of a muffler in accordance with the subject invention.

FIG. 2 is a perspective view of the muffler of FIG. 1 shown in its assembled condition.

FIG. 3 is a top plan view of the muffler shown in FIG. 2.

FIG. 4 is a bottom plan view of the muffler shown in FIG. 2.

FIG. 5 is a side elevational view of the muffler shown in FIG. 2 and mounted on a vehicle.

FIG. 6 is a cross section taken along line 6-6 in FIG. 5.

FIG. 7 is a cross-sectional view taken along line 7-7 in Fig. 6.

FIG. 8 is an elevational view of an alternate muffler mounted on a vehicle and viewed from the rear of the vehicle.

FIG. 9 is a top plan view of the muffler shown in FIG. 8.

FIG. 10 is a side elevational view of the muffler shown in FIG. 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A muffler in accordance with the subject invention is illustrated in FIGS. 1-7, and is identified generally by the numeral 10. The muffler 10 comprises a pair of internal plates 12 and 14 and a pair of external shells 16 and 18. The muffler 10 is of the type generally referred to as a resonator, and, as explained herein, is operative to attenuate two distinct and relatively narrow frequency ranges of noise. The muffler 10 typically would be employed in combination with at least one other muffler that would be operative to attenuate a generally broader range of exhaust gas noise frequencies. Alternatively, the internal plates 12 and 14 shown herein could be of different configuration to achieve a broader range of sound attenuation.

The internal plate 12 is stamp formed to define a pair of inlet channels 20 and 22 which extend from peripheral locations 21 and 23 on the internal plate 12 toward a confluence 24 at which the inlet channels 20 and 22 communicate with one another. The stamp formed internal plate 12 further comprises an outlet channel 26 which extends from the confluence 24 to peripheral location 28 on the internal plate 12. Tuning channels 30 and 32 communicate with the outlet channel 26 at locations 33 and 31 respectively The tuning channel 30 terminates at a tuning aperture 34. However, tuning channel 32 defines an enclosed end 35.

The stamped internal plate 14 is dimensioned to be placed in register with the internal plate 12. More particularly, the internal plate 14 includes inlet channels 40 and 42 which extend from peripheral locations 41 and 43 respectively to confluence 44. The internal plate 14 further comprises an outlet tube 46 extending from the confluence 44 to a peripheral location 48. The internal plate 14 is stamp formed to define tuning channels 50 and 52 which extend from the outlet channel 46 at locations 53 and 51 respectively. The tuning channel 52 terminates at a tuning aperture 54, while tuning channel 50 terminates at a closed end 55.

The inlet channels 20 and 22 and the outlet channel 26 of the internal plate 12 are stamped to be in register with the inlet channels 40 and 42 and the outlet channel 46 of the internal plate 14 to define a pair of inlet tubes and an outlet tube which are connectable respectively to nipples 56, 57 and 58 which in turn are connectable to the exhaust pipes and tail pipe of a vehicle. In other embodiments, the tubular members 56, 57 and 58 may comprise portions of the exhaust pipes and tail pipe without the use of separate nipples. The tuning channels 30 and 32 of the internal plate 12 are disposed to be in register with the tuning channels 50 and 52 of the internal plate 14 to define a pair of tuning tubes. The tuning tube defined by tuning channels 30 and 50 communicates with a low frequency resonating chamber through tuning aperture 34 in the internal plate 12. The tuning tube defined by tuning channels 32 and 52 communicates with a separate low frequency resonating chamber through the tuning aperture 54 in the internal plate 14. The length and cross-sectional

dimensions of the tuning channels 30, 32, 50 and 52 are carefully selected in accordance with the specific ranges of exhaust gas noise frequency to be attenuated by the muffler 10. Similarly, the volumes of the respective low frequency resonating chambers with which the respective tuning tubes will communicate also will be selected in accordance with the specific noise frequencies to be attenuated.

The external shell 16 includes a peripheral flange 59 which is dimensioned and configured to engage the peripheral portion of the internal plate 14. The portion of the external shell 16 disposed inwardly from the peripheral flange 59 defines a low frequency resonating chamber 60 which will communicate with the tuning aperture 54 stamped in the internal plate 14. The volume defined by the low frequency resonating chamber 60 is selected in view of the length and cross-sectional area of the tuning tube defined by channels 32 and 52 to attenuate a specific range of noise frequencies. It will be noted that the configuration of the low frequency resonating chamber 60 is such that substantially the entire chamber 60 is of convex configuration when viewed from the exterior of the muffler 10. Additionally, it will be noted that the low frequency resonating chamber 60 is characterized by reinforcing ribs 61 which are stamped therein to substantially minimize or prevent the propagation of radiated noise or shell noise.

The external shell 18 includes a peripheral flange 62 which is configured and dimensioned to abut the peripheral portion of the stamped internal plate 12. The external shell 18 is stamp formed to define a low frequency resonating chamber 64 that will communicate with the tuning tube formed by tuning channels 30 and 50 through the tuning aperture 34. The total volume defined by the low frequency resonating chamber 64 of the external shell 18 is selected in view of the particular length and cross-sectional area of the tuning tube defined by channels 30 and 50 and the frequency of the noise to be attenuated.

The low frequency resonating chamber 64, unlike the chamber 60 in the external shell 16, is not uniformly convex when viewed externally. Rather, the low frequency resonating chamber 64 includes an elongated conformal area 66 of generally arcuate concave configuration when viewed from the outside of the muffler 10. More particularly, the low frequency resonating chamber 64 comprises a pair of generally planar walls 68 and 69 extending away from the peripheral flange 62 from opposite longitudinal sides of the external shell 18 and converging toward one another to substantially conform to the shape of the interference zone 70 surrounding the passenger compartment 71. The converging surfaces 68 and 69 terminate at elongated spaced apart ridges 72 and 74. As shown most clearly in FIG. 6, the ridges 72 and 74 are generally convex when viewed from the exterior of the muffler 10 and define generally small radius curves. A chordal plane P extending between the ridges 72 and 74 would be spaced from the conformal area 66 disposed intermediate the ridges 72 and 74. The conformal area 66 is dimensioned and configured to substantially follow the shape of the interference zone 76 surrounding the drive shaft 78 of a vehicle. As a result, the chordal plane P extending between the ridges 72 and 74 would intersect both the interference zone 76 and the drive shaft 78. It will be understood that in certain embodiments the shape of the concave conformal zone may be selected such that a plane comparable to chordal plane P would pass through the interference zone but would be tangent to or slightly spaced from the structure of the vehicle about which the interference zone is disposed.

A second embodiment of a muffler in accordance with the subject invention is illustrated in FIGS. 8-10 and is identified generally by the numeral 80. The muffler 80 may be employed in conjunction with the resonator/muffler 10 described above or may be employed independent of any other muffler. The muffler 80 comprises internal plates 82 and 84 and external shells 86 and 88. The internal plates 82 and 84 are secured in juxtaposed relationship and are stamp formed to define an array of tubes therebetween. The tubes defined by the stamp forming of internal plates 82 and 84 comprise an inlet connectable to nipple 90 or to the exhaust pipe and an outlet connect able to nipple 92 or to the tail pipe. The configuration of the tubes stamped in the internal plates 82 and 84 and disposed intermediate the nipples 90 and 92 will be selected in accordance with the particular noise characteristics of the vehicle onto which the muffler 80 is mounted. For example, the internal plates 82 and 84 may comprise arrays of perforations and at least one tuning tube as disclosed in the above identified U.S. Patent No. 4,700,824 or in the above cited co-pending applications.

The external shell 86 is disposed to face the road or other surface on which the vehicle is supported. Thus, the external shell 86 defines a profile which generally conforms to the established sight line S for the vehicle and the ramp clearances. The external shell 86 comprises a peripheral flange 94 which is configured and dimensioned to be placed in register with the peripheral portion of the internal plate 82. The remainder of the external shell 86 defines a chamber 96 which is substantially entirely convex when viewed from the exterior of the muffler 80.

The external shell 88 includes a peripheral flange 102 which is configured and dimensioned to

be secured to the internal plate 84. The external shell 88 defines a chamber 104 disposed inwardly from the peripheral flange 102. However, the external shell 88 is not substantially uniformly convex when viewed from the exterior of the muffler 80. More particularly, the chamber 104 is defined by opposed generally converging long and short end walls 106 and 108 which converge upwardly from the peripheral flange 102. Opposed side walls 110 and 112 also converge upwardly from the peripheral flange 102 and extend between and connect the end walls 106 and 108. Top wall 114 is connected to the long end wall 106 and portions of the side walls 110 and 112.

The conformal area of the external shell 88 is indicated generally by the numeral 116 and is formed by walls 118 and 120 which intersect at an internal corner 122. More particularly, the walls 118 and 120 diverge from the corner 122 to join with the short end wall 108 and the top wall 114 at external corners 124 and 126 respectively. The configuration of the conformal area 116 is selected to conform to the interference zone 128 which surrounds the structural component 130 of the vehicle on which the muffler 80 is mounted. For example, the structural component 130 may comprise the spare tire well or trunk of the vehicle. With this configuration, a plane P' extending between the corners 124 and 126 will pass through the interference zone 128 of structure 130, and in this particular embodiment will also pass through the structure 130. As noted with the previous embodiment, this configuration enables the muffler 80 to conform to the available space on the vehicle. As a result, the volume required for the chamber 104 can be achieved by efficiently utilizing as much of the odd-shaped available space as is required.

In summary, a stamp formed muffler is provided with a plurality of plates stamped to define an array of tubes therebetween, including at least one inlet and at least one outlet. At least one external shell is secured to one of the stamped plates. The external shell is configured to define at least one chamber which communicates with the array of tubes defined by the plates. The external shell includes a generally concave conformal area which is configured to conform to the shape of a structure on the vehicle. The conformal area of the external shell may comprise an arcuate concave area or an internal corner when viewed from the exterior of the muffler. Thus, a plane extending across the conformal area will pass through at least the interference zone surrounding the structure on the vehicle or through the structure itself.

While the invention has been described with respect to certain preferred embodiments, it is apparent that various changes can be made without departing from the scope of the invention as defined by the appended claims.

Claims

1. An exhaust muffler for mounting in proximity to a generally convex structure on a vehicle, said muffler comprising:
a plurality of plates secured in face-to-face relationship and formed to define at least one inlet and at least one outlet for said muffler and at least one tube extending therebetween; and
an external shell secured to at least one of said plates and defining at least one chamber in communication with said tube, said external shell comprising a generally concave conformal area conforming to the shape of at least a portion of said structure, said conformal area being configured such that at least one line connecting spaced apart locations on said conformal area passes through said structure when said muffler is mounted to said vehicle.

2. A muffler as in claim 1 wherein said conformal area is configured to be approximately uniformly spaced from said structure of said vehicle by a distance approximately equally to a minimum acceptable clearance between said structure and said muffler to define an interference zone between said structure and said muffler.

3. An exhaust muffler for mounting in proximity to a generally convex arcuate structure on a vehicle, said muffler comprising:
a pair of plates secured in face-to-face relationship, said plates being formed to define at least one inlet and at least one outlet to said muffler and at least one tube extending therebetween; and
at least one external shell secured to said plates and defining at least one chamber in communication with said tube, said external shell defining an inwardly concave arcuate conformal area generally conforming to the shape of said arcuate structure of said vehicle and spaced therefrom to define an interference zone between said arcuate structure and said muffler such that chordal lines extending between selected points on said concave conformal area of said external shell pass through said interference zone when said muffler is mounted to said vehicle.

4. A muffler as in claim 3 wherein selected ones of said chordal lines extend through said arcuate structure.

5. A muffler as in claim 3 wherein said vehicle comprises a drive shaft which defines said arcuate structure of the vehicle, and wherein the concave

conformal area of said external shell is approximately equally spaced from and concentric with said drive shaft.

6. An exhaust muffler for mounting in proximity to a generally polyhedral structure on a vehicle, said generally polyhedral structure comprising a plurality of surfaces intersecting to define an outwardly directed corner on said vehicle, said muffler comprising:
a pair of plates secured in face-to-face relationship, said plates being formed to define at least one inlet and at least one outlet to said muffler and at least one tube extending therebetween; and
at least one external shell secured to at least one of said plates and defining at least one chamber in communication with said array of tubes, said external shell comprising a plurality of intersecting surfaces, at least two of said surfaces intersecting at an inwardly directed corner to define a conformal area, said conformal area of said external shell generally conforming to the shape of the intersecting surfaces defining the outwardly directed corner of said polyhedral structure on said vehicle.

7. An exhaust muffler for mounting on the underside of a vehicle and in proximity to the trunk well of said vehicle, said trunk well comprising at least one outwardly directed corner, said muffler comprising:
a pair of plates secured in juxtaposed relationship and formed to define at least one inlet and at least one outlet to said muffler and at least one tube extending therebetween; and
at least one external shell secured to at least one of said plates, said external shell being formed to comprise a plurality of intersecting walls, said walls defining at least one chamber of said muffler, at least two of said walls intersecting to define an inwardly directed conformal area substantially conforming to the shape of the outwardly directed corner of said trunk well.

8. An exhaust muffler for mounting in proximity to a generally convex structural component on a vehicle, an interference zone at least partly surrounding said generally convex structural component, and defining a minimum acceptable clearance between said structural component and said muffler, said muffler comprising:
a plurality of plates secured in face-to-face relationship and formed to define at least one inlet and at least one outlet for said muffler and at least one tube extending therebetween; and
an external shell secured to at least one of said plates and defining at least one chamber in communication with said tube, said external shell comprising a generally concave conformal area generally conforming to the shape of at least a portion of the interference zone surrounding said structural component, said conformal area being configured such that at least one line connecting spaced apart locations on said conformal area passes through said interference zone when said muffler is mounted to said vehicle.

9. An exhaust muffler for mounting on the underside of a vehicle, said underside of said vehicle comprising at least one convex surface and at least one concave surface, said convex and concave surfaces of said vehicle being in proximity to one another, said muffler comprising:
a plurality of plates secured in face-to-face relationship and formed to define at least one inlet and at least one outlet for said muffler and at least one tube extending therebetween; and
an external shell secured to at least one of said plates and defining at least one chamber in communication with said tube, said external shell comprising both convex and concave portions generally conforming to the shape of selected convex and concave surfaces on the underside of the vehicle, whereby said muffler can be mounted in nested relationship to said selected convex and concave surfaces on the underside of said vehicle.

10. An exhaust muffler for mounting in proximity to a generally convex structure on a vehicle, said muffler comprising:
an array of tubes comprising at least one inlet and at least one outlet for said muffler; and
a pair of external shells secured to one another and around said array of tubes, one said external shell comprising a generally concave conformal area conforming to the shape of at least a portion of the structure, whereby said conformal area can be disposed in generally nested relationship to said structure when said muffler is mounted to said vehicle.

11. A muffler as in claim 1 wherein said generally concave conformal area is of generally arcuate configuration.

12. A muffler as in claim 1 wherein said generally concave conformal area comprises an inwardly directed corner on said muffler defined by two intersecting surfaces.

13. A muffler as in claim 3 wherein said external shell of said muffler comprises a pair of outwardly convex ridges adjacent to and defining the limits of said concave conformal area.

14. A muffler as in claim 13 wherein said ridges lie generally within a common plane, said plane extending through the interference zone surrounding said arcuate structure of said vehicle.

15. A muffler as in claim 14 wherein said ridges are generally parallel to one another.

16. A muffler as in claim 6 wherein at least one of said surfaces defining said conformal area is generally planar.

17. A muffler as in claim 6 wherein at least one of said surfaces defining said conformal area is generally arcuate.

18. A muffler as in claim 6 wherein the angle defined by the inwardly directed corner on said muffler approximately equals the angle defined by the outwardly directed corner on said structure.

19. A muffler as in claim 6 wherein each of said surfaces of said conformal area comprises at least one location most distant from said inwardly directed corner, and wherein a line connecting said most distant locations on the respective surfaces of said conformal area passes through said polyhedral structure of said vehicle.

20. A muffler as in claim 7 wherein said external shell with said conformal area defines a first external shell, and wherein said muffler further comprises a second external shell secured to at least one of said plates and stamp formed to define at least one chamber in communication with said array of tubes, said second external shell being of generally convex configuration.

21. A muffler as in claim 8 wherein said conformal area is of generally arcuate concave configuration.

22. A muffler as in claim 8 wherein said generally concave conformal area comprises an inwardly directed corner on said muffler defined by two intersecting surfaces.

23. A muffler as in claim 8 wherein said conformal area is approximately uniformly spaced from said structural component of said vehicle.

24. A muffler as in claim 23 wherein said conformal area is of generally arcuate concave configuration.

25. A muffler as in claim 23 wherein said conformal area comprises an inwardly directed corner on said muffler defined by two intersecting surfaces.

26. A muffler as in claim 23 wherein said conformal area is configured to be approximately uniformly spaced from said structure when said muffler is mounted on said vehicle.

27. An exhaust system for a vehicle, said vehicle comprising an internal combustion engine, a generally cylindrical drive shaft and a trunk well comprising a plurality of intersecting surfaces defining at least one outwardly directed corner, said exhaust system comprising:

a resonator in communication with said engine, said resonator comprising a pair of plates secured in juxtaposed relationship, said plates being stamp formed to define an array of tubes therebetween, said array of tubes com prising at least one inlet, at least one outlet and first and second tuning tubes, said first tuning tube terminating at an aperture extending through one said plate, and the second tuning tube terminating at an aperture extending through the second of said plates, said resonator further comprising first and second external shells secured respectively to said plates, said external shells being stamp formed to define low frequency resonating chambers in communication respectively with said tuning tubes, said first external shell comprising an elongated generally arcuate concave conformal area conforming generally to the shape of said drive shaft, to enable said resonator to be mounted in close proximity to said drive shaft; and

a muffler comprising a pair of plates secured in juxtaposed relationship, said plates being stamp formed to define an array of tubes therebetween, said array of tubes comprising an inlet for communication with the outlet of said resonator and at least one outlet, said muffler further comprising a pair of external shells secured to said plates and defining at least one chamber in communication with said array of tubes of said muffler, one said external shell comprising an inwardly directed conformal area defined by a plurality of intersecting surfaces, said conformal area generally conforming to the shape of the outwardly directed corner of said trunk well.

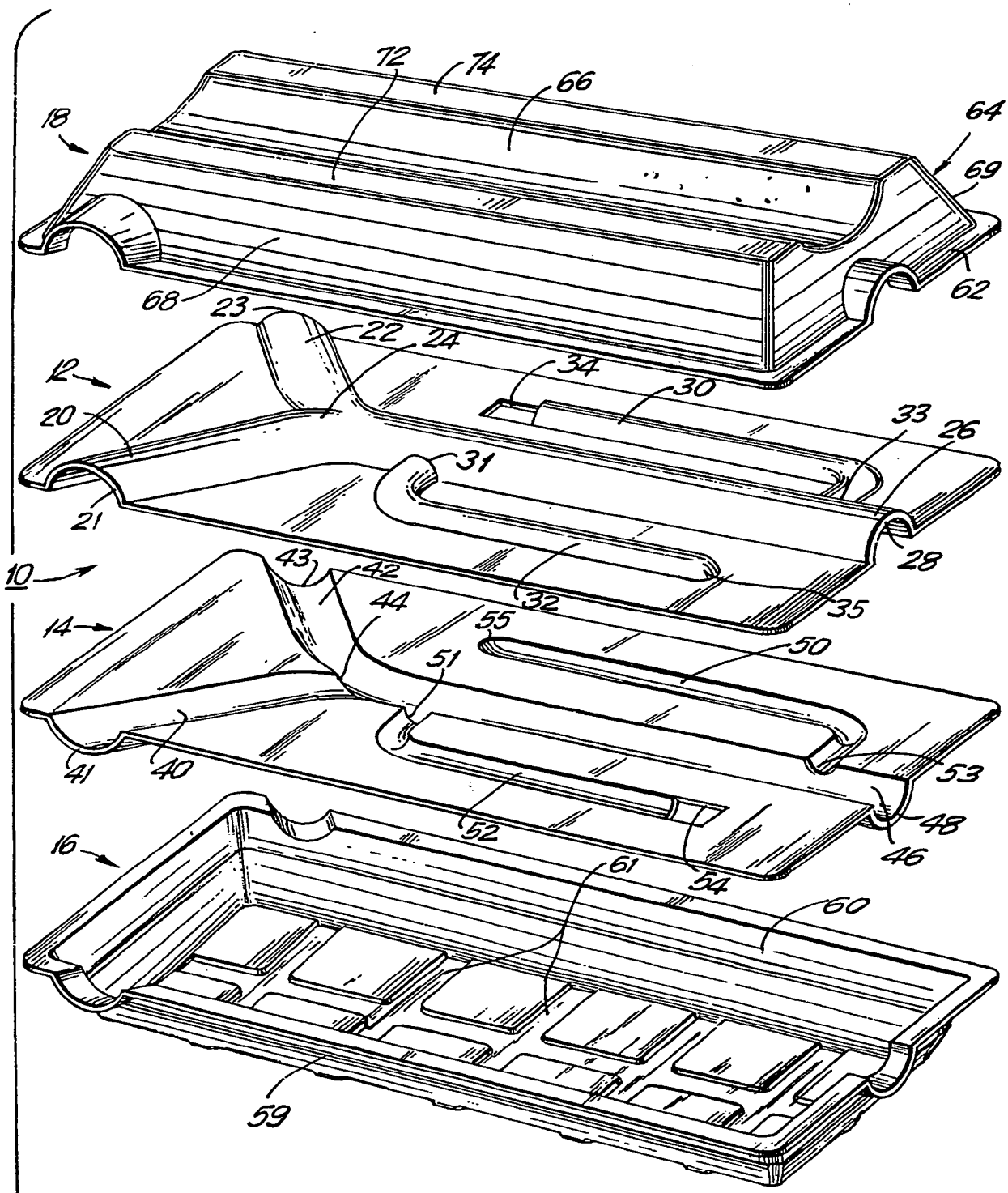

FIG. 1

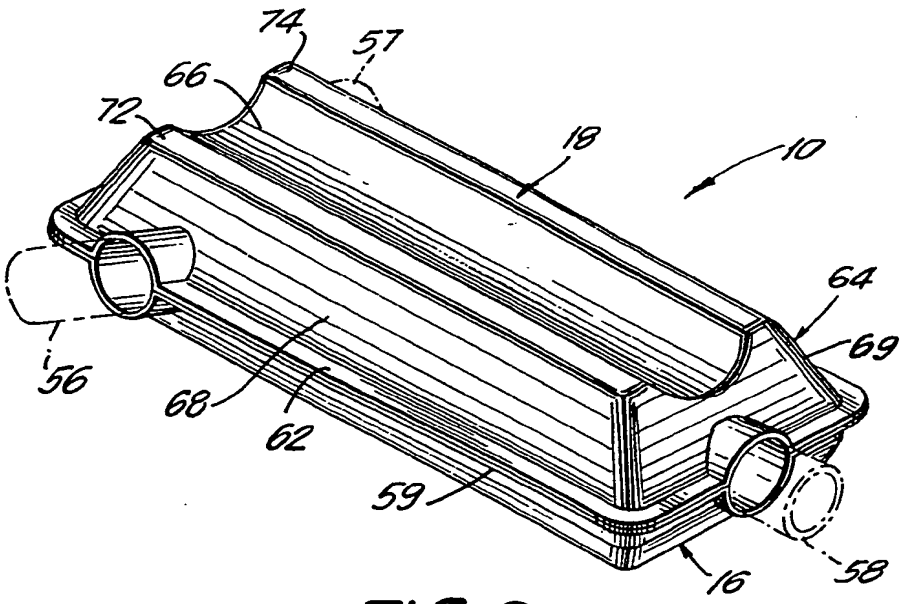

FIG.2

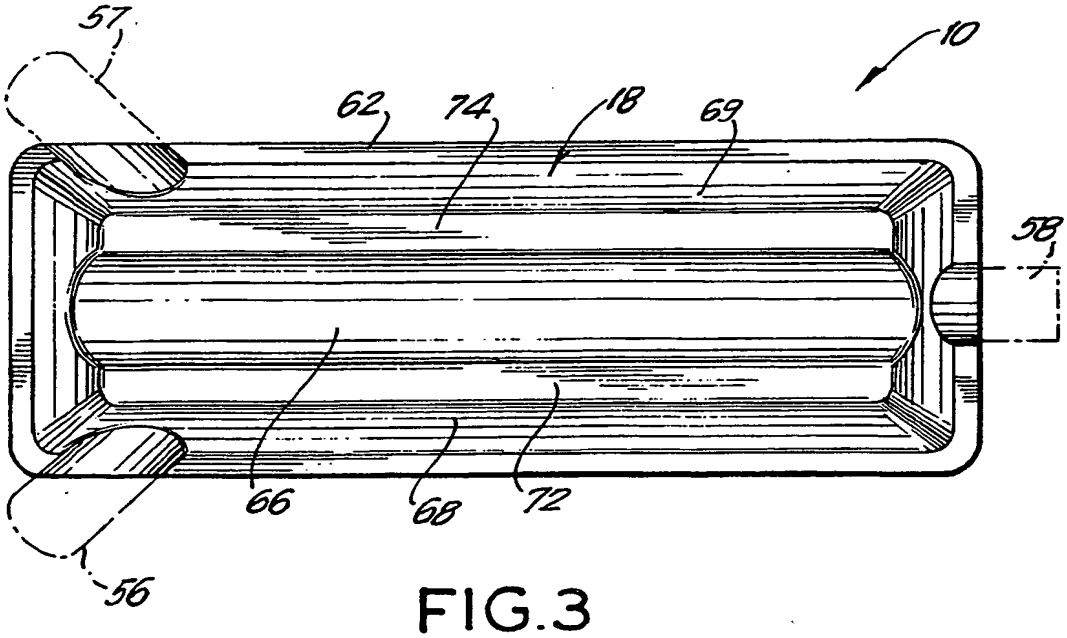

FIG.3

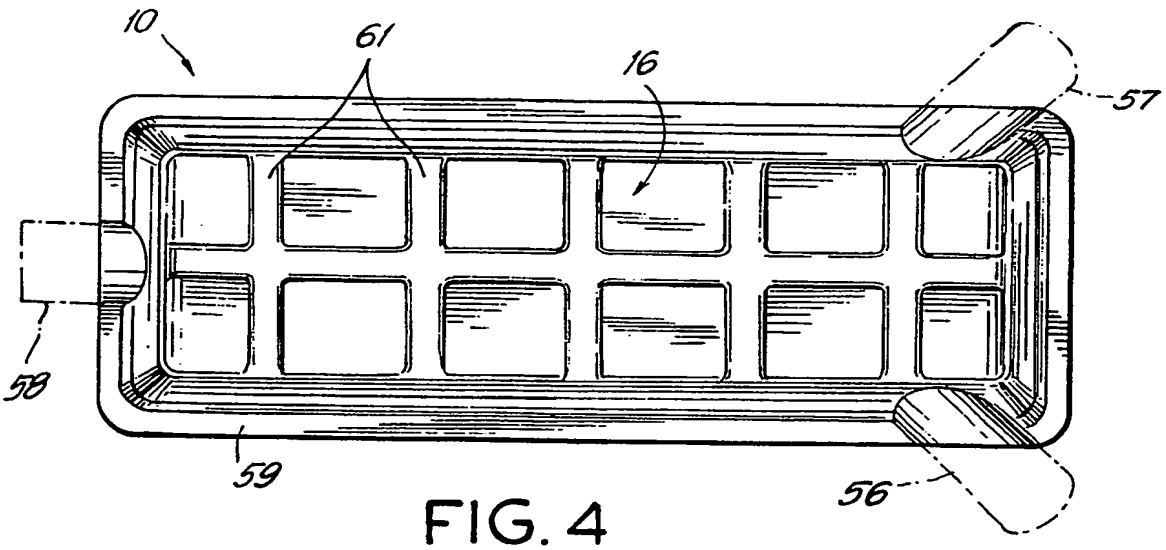

FIG. 4

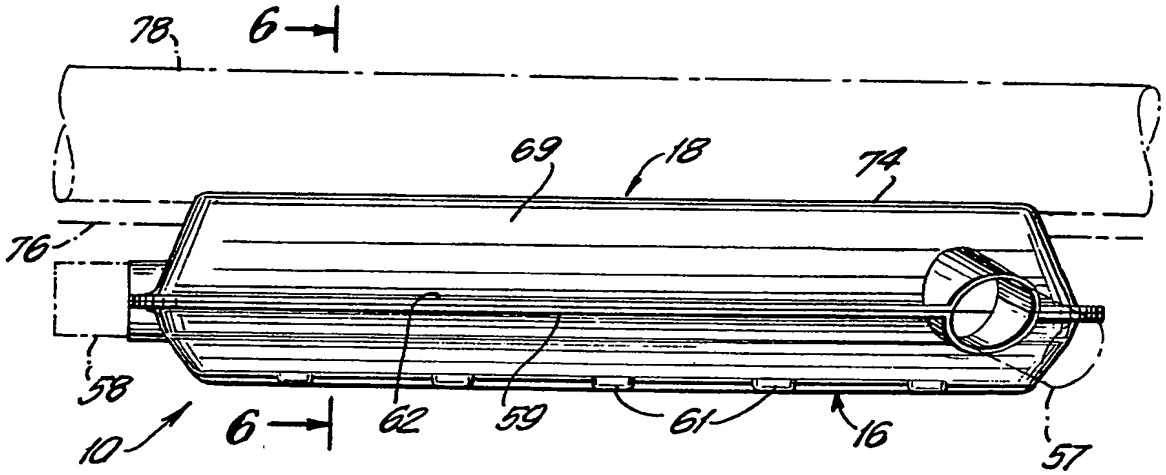

FIG. 5

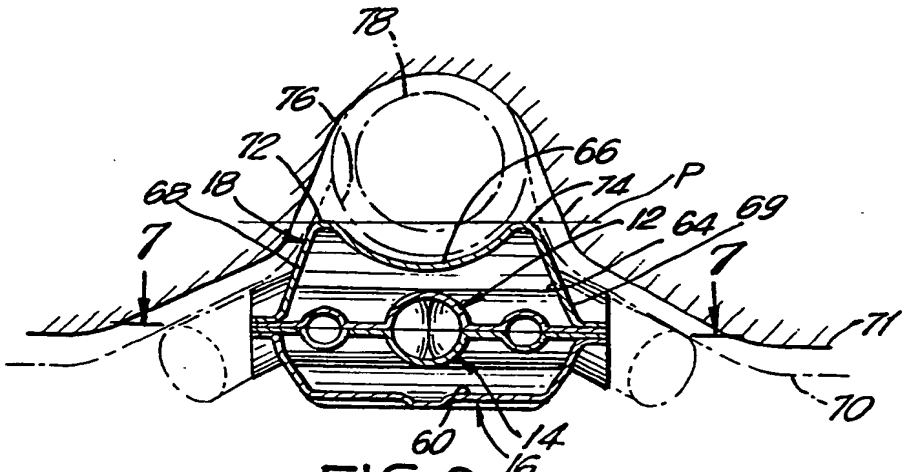

FIG. 6

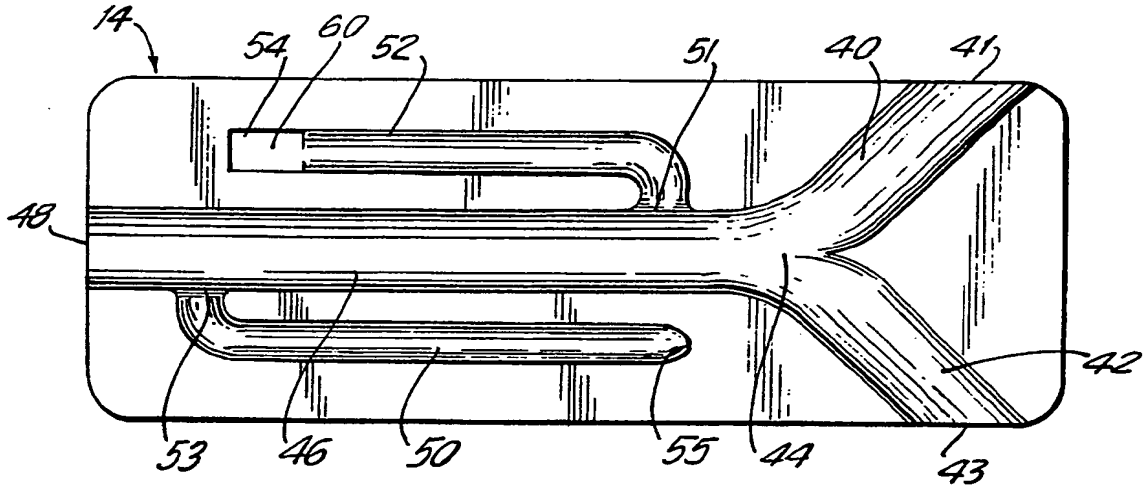

FIG.7

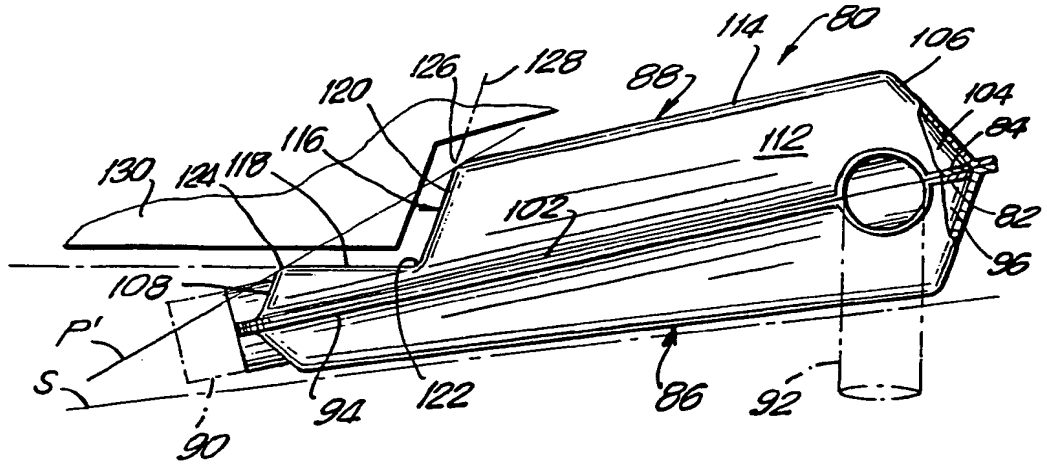

FIG.8

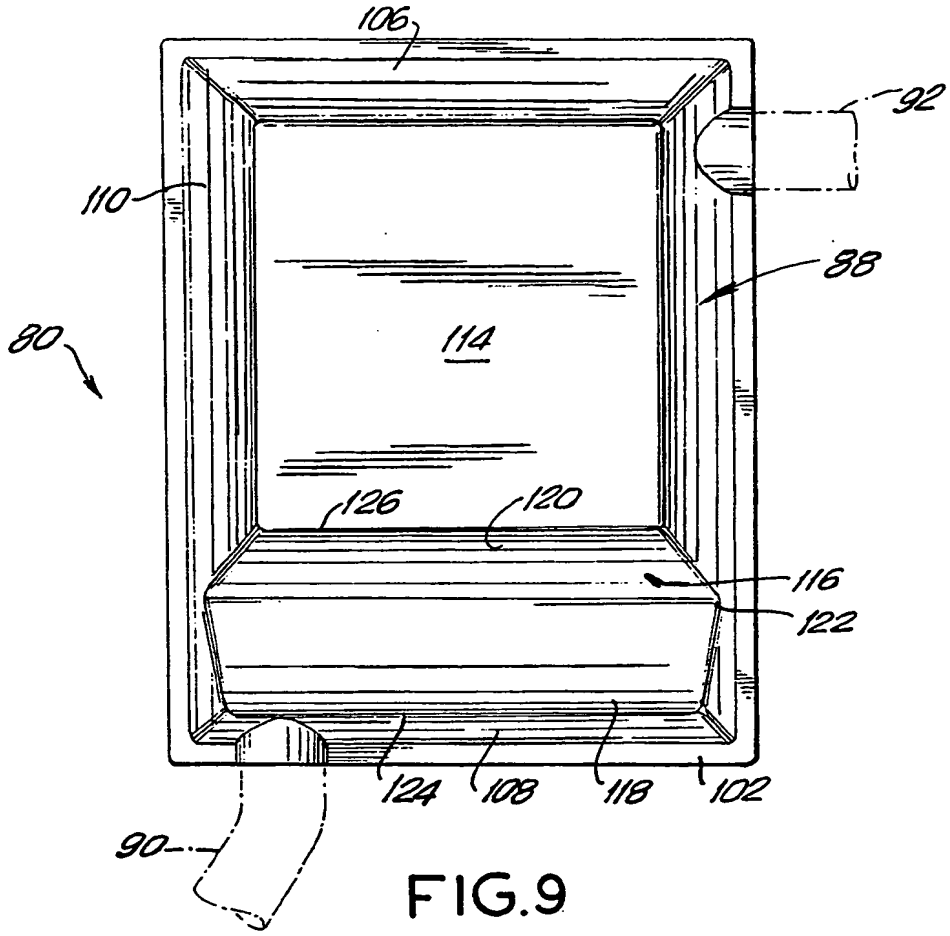

FIG.9

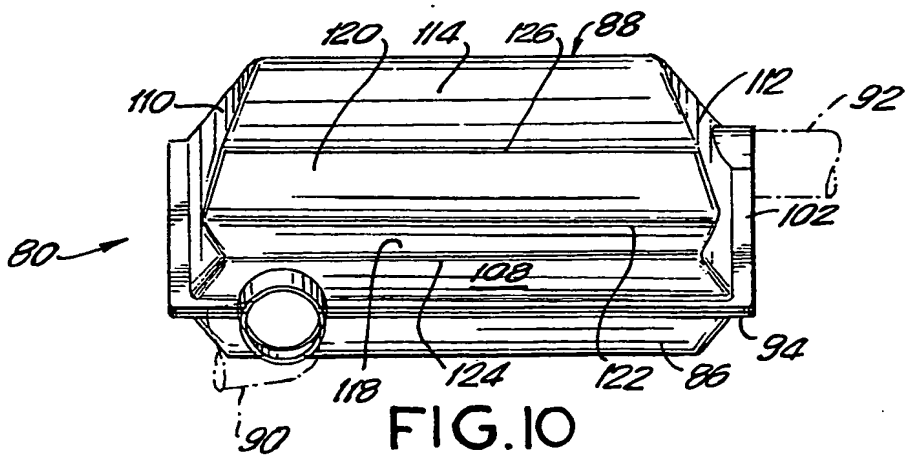

FIG.10

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 10 9058

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A,D	US-A-4 700 806 (HARWOOD) * Column 3, lines 46-57; column 5, line 21 - column 8, line 31; figures 1-4 *	1,3,6-10,20,27	F 01 N 7/18 F 01 N 1/02
A,D	US-A-4 132 286 (HASUI) * Column 6, line 26 - column 8, line 7; figures 9-13 *	1,3,6-10,20,27	
A,D	GB-A- 632 013 (BRITISH LIGHT STEEL PRESSINGS) * Page 3, lines 12-95; figures 1-11 *	1,3,6-10,20,27	
A	GB-A-1 309 141 (CASSEL) * Page 1, line 77 - page 2, line 10; page 4, line 31 - page 5, line 51; figures 1-3 *	1,6,7,9,10	
A	US-A-2 658 580 (TREMBLEY) * The whole document *	1,9	
A	US-A-1 634 000 (SMITH)		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	US-A-4 719 988 (KINOUCHI)		F 01 N B 60 K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12-12-1988	FRIDEN C.M.

CATEGORY OF CITED DOCUMENTS

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